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***Abstract*—By using the analytical equations of the no-load flux density obtained with a two-dimensional model (2D) in polar coordinates, the authors proposed to interpolate a new analytical expression of the optimal thickness of the magnet which make it possible to maximize the no-load flux density in the air-gap. The interpolation function of the magnet optimal thickness could be utilized for surface mounted permanent magnet motors having a direction of parallel or radial magnetization [1].**

I. Introduction

Generally, in the optimization processes of the synchronous permanent magnet machines, one always try to minimize the thickness of the magnet. The minimal value of the magnet thickness is limited to avoid demagnetizing armature reaction field and this thickness must be sufficient to reach good performances. However, this optimization criteria is not enough to obtain the best performances of a motor. Indeed to improve the precision of optimization's calculation, it would be interesting to choose the thickness of the magnet between the demagnetization limit and the maximal limit obtained by maximizing the no-load flux density of the air-gap. By using the no-load flux density analytical equations obtained with a 2D model in polar coordinates which includes both parallel and radial magnetization [1], the authors propose to interpolate a new analytical expression of the magnet optimal thickness which make it possible to maximize the no-load flux density in the air-gap and, consequently, to improve the motor's performances (average torque, efficiency, etc.).

II. An Analytical Expression of the Magnet Optimal Thickness

By using the radial and tangential components of the no-load flux density produced by the magnets in Region.I (i.e. in the air-gap modified by Carter's coefficient) [1] and the equations describing the geometrical structure (i.e. $R_m = R_s' - g'$ and $R_r = R_m - h_m = R_s' - g' - h_m$), one notices that the parameters which have an influence on the no-load flux density in Region.I are: the inner stator radius modified by Carter's coefficient, R_s', the thickness of the magnet, h_m, the air-gap modified by Carter's coefficient, g', the magnet pole-arc to pole-pitch ratio (**fixed**), $\alpha_p = 1$, the number of pole pairs (**fixed**), $p = 1$.

One can remark, in Fig. 1, that above a thickness of the magnet the no-load flux density in Region.I decreases. This reduction is due to the leakages between the two magnets. Thus, there is an optimal thickness of the magnet, $h_{m_{max}}$, which gives a maximum level of no-load flux density in the Region.I [2].

To be able to incorporate this behaviour in design model, a numerical approximation was done. An original interpolation function of the magnet optimal thickness is proposed:

$$h_{m_{max}} = k_1 \cdot \frac{{R_m}^{k_2}}{{R_s'}^{k_2-1}} \cdot \left[k_3 - k_4 \cdot \left(\frac{R_m}{R_s'} \right)^{k_5} \right]^{k_6} \qquad (1)$$

The coefficients k_1, k_2, k_3, k_4, k_5 et k_6 of the interpolation function are determined by application of a non-linear method, Levenberg-Marquardt type, in order to minimize the error with the points calculated by the analytical model.

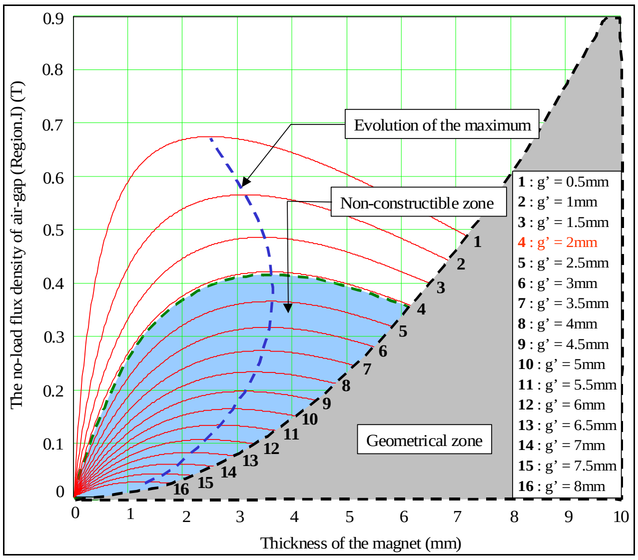

Fig. 1. The evolution of the no-load flux density in Region.I according to the thickness of the magnet for a radial magnetization, for various values of the air-gap modified by Carter's coefficient and for $R_s' = 10$ mm.

III. Conclusion

An analytical expression of the magnet optimal thickness has been proposed. Indeed, the authors of this article have showed that there is a new optimal thickness of the magnet which gives a maximum level of no-load flux density in the air-gap and, consequently, makes it possible to improve the motor's performances (average torque, efficiency, etc.). It will be detailed in the final paper.

The modeling of the no-load flux density [1] and the use of the interpolated magnet thickness function, equation (1), make it now possible to maximize the no-load flux density of the air-gap in the dimensioning model. The next stage of this work is to generalize the interpolation function for various magnet pole-arc to pole-pitch ratio, α_p, and various number pole pairs, p.

IV. References

[1] F. DUBAS, C. ESPANET & A. MIRAOUI –*"**Analytical Modeling of No-Load Flux Density in Surface Mounted Permanent Motors**"*, ACEMP'2004 (Notification of acceptance: 15 January 2004).

[2] F. DUBAS, C. ESPANET & A. MIRAOUI – *"**Modélisation analytique et maximisation de l'induction magnétique à vide d'un moteur à aimants montés en surface**"*, EF'2003, 9 et 10 Décembre 2003.